Design of an assistive device for older age people suffering from essential tremor

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In

Industrial Design

By

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Declaration

We Hereby Declare That This Thesis Is Our Own Work And Effort. Throughout This Documentation Wherever Contributions Of Others Are Involved, Every Endeavour Was Made To Acknowledge This Clearly With Due Reference To Literature. This Work Is Being Submitted For Meeting The Partial Fulfilment For The Degree Of Bachelor Of Technology In Industrial Design At National Institute Of Technology, Rourkela For The Academic Session 2011 – 2015.

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Certificate of Approval

This is to certify that the thesis entitled "**DESIGN OF AN ASSISTIVE DEVICE FOR OLDER AGE PEOPLE SUFFERING FROM ESSENTIAL TREMOR**" submitted to the National Institute of Technology, Rourkela by **DEBASHISH BEHERA**, **Roll No. 111ID0266** and **MANISHA MOHANTY**, **Roll No. 111ID0603** for the award of the Degree of Bachelor of Technology in Industrial Design Engineering is a record of bona fide research work carried out by then under my supervision and guidance. The results presented in this thesis has not been, to the best of my knowledge, submitted to any other University or Institute for the award of any degree or diploma. The thesis, in my opinion, has reached the standards fulfilling the requirement for the award of the degree of Bachelor of technology in accordance with regulations of the Institute.

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Abstract

Essential tremor (ET) is a nerve disorder characterized by uncontrollable shaking, or "tremors," in different parts and on different sides of the body. Areas affected often include the hands, arms, head, larynx (voice box), tongue, and chin. The lower body is rarely affected. ET is not a life-threatening disorder, unless it prevents a person from caring for him or herself. Essential tremor is characterised by rhythmic shaking that occurs during voluntary movement or while holding a position against gravity. The two types of tremor include: Action tremor – a voluntary movement such as lifting a cup to one's mouth and Postural tremor – a voluntary holding of a position against gravity such as reaching or extending one's hand or arm. Most people with essential tremor experience both postural and action tremor.

Most people are able to live normal lives with this condition -- although they may find everyday activities like eating, dressing, or writing difficult. It is only when the tremors become severe that they actually cause disability. So, the aim of this project is to design an assistive device for older age people suffering from essential disorder which can be able to nullify the tremor produced in the hand with maximum percentage of efficiency and ergonomically designed for easy use. The main objective of the project is focusing on the design of an intelligent device that can recognize the tremor automatically by differentiating the frequency at normal stage and at the shaking stage in order to accomplish the neutralizing effect in the shortest possible time.

Keywords: Essential Tremor, assistive device, action tremor, postural tremor.

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1. Introduction

Essential tremor (ET) is one of the most common neurological disorder and has influenced individuals from the earliest starting point of cutting edge human presence. Essential tremor is characterized by uncontrollable shaking or tremors in different areas of the body like hands, arms etc. It often affects activities of daily living, including writing and eating. The persistence of ET increases with advancing age and is usually characterized by presence of postural and kinetic tremor. When the hands are utilized, tremors intensify and then attenuate to a larger extent when the hands come to rest. Also the condition worsens when people affected with ET, hold their body is certain postures (posturaltremor). Essential tremor progressively deteriorates over the long run and with growing age. The reason is obscure and there hardly exists any cure, in spite of the fact that medications and surgery may offer assistance. Older people are more vulnerable [1].

Figure1. Essential Tremor in hands [1]. The movement or shaking of hand during rest.

In this paper the work is based on the development of sensor based assistive device for neutralizing tremor in hands of old people. The project aims for the design of an intelligent device which recognizes the tremor automatically by differentiating the frequency at normal stage and at the shaking stage in order to accomplish the neutralizing effect in the shortest possible time. In order to develop the small scaled model of this device, the main idea is behind investigating the average frequency of shaking of hands during relaxed posture, postural conditions, action conditions, transition positions etc. and to find out the require time to achieve the task. Experiment show that the system is robustness and well positioned with different frequencies to achieve the targeted task of nullifying the tremor produced in the hands with maximum percentage of efficiency and ergonomically designed for efficient use.

1.1 Background

Essential Tremor being the most common neurological disorder affects mostly the older age people. The tremor usually involves the arms, fingers and hands. Essential tremor is common in people older than 65. The cause behind essential tremor is not known till date. If essential tremor happens to exist in two or more members of a family, it is called a

familial tremor. This sort of essential tremor is passed down through families (inherited). This happens to say that genes assume a part in its cause. [5] Thus it affects the daily based activities like holding something, writing, eating or doing household chores. It is observed that with apprehension, oppression, and intake of caffeine, the tremor intensifies. The tremor can also have a significant psychological impact on the patient, because it usually gets worse in social situations. Thus, ET affects people physically as well as psychologically.

1.2 Motivation

With the growing number of people suffering from Essential Tremor and the increasing number of problems being faced by them, this neurological disorder is becoming a major problem and to counter this problem is a major challenge as well. Being aware with this challenge, this project is a stepping stone towards solving this problem to some extent.

1.3 Problem Definition

Most people are able to live normal life with this condition. Although essential tremor usually occurs with movements, thus the people affected with ET face difficulties while doing everyday activities like eating, drinking or writing. Also when the hands get extended, ET occurs since the muscles are opposed to the gravity. Thus it is evident that essential tremor interferes with the everyday activities.

Notwithstanding the hands and arms, muscles of the face, head, and neck might likewise show tremor in this issue. In this project, we take the case of ET produced in hands and palms. The older people often feel embarrassed to have their food infront of other people due to the tremor produced in their hands. They become very conscious while having their food or drinking water or even writing. This affects their conscience. They feel very low. So the main problem lurks behind the neutralization of the tremor produced in the hands while doing activities.

Some common problems that old age people face are:

- Intractable tremors that onsets during eating.
- Hand shivering during writing.
- Difficulty in balancing when grasping or holding something.

- Emotional activation and stress due to tremor.
- Worsening of tremor with intended movement.

These problems make the older age people feel embarrassed while having a meal or pastime with others.

1.4 Objective of Work

In this project we analyse the tremor that is produced in the hands of older people, their average frequency of oscillation and the problems faced by the older people with ET. Keeping in mind the various problems faced by older people with ET, the work that is presented here is an attempt to design an assistive device for older age people suffering from essential disorder which can be able to nullify the tremor produced in the hand with maximum percentage of efficiency and ergonomically designed for easy use and simultaneously help them perform their daily activities without any problems.

The main objectives of the work are stated as follows:-

- Aiming on the design of an intelligent sensor based device that can perceive the tremor produced in the hands of older people while they perform their daily activities like eating, drinking, and writing.
- The device would recognize automatically by differentiating the frequency at normal stage and at the shaking stage in order to accomplish the neutralizing effect in the shortest possible time.
- The device should be easy to carry and ergonomically designed to provide comfort while using it.
- The device being used by older people should be easy to operate and handle.

1.5 Symptoms of Essential Tremor

Patients with essential tremor may exhibit the following signs and symptoms [2]:

- Tremor outsets from one extremism and advances to other extremism.
- Initially tremor is not frequent, and appears periodically during emotional trigger, and finally continues to stay over time.
- Head, lips, face, voice and jaw are also affected.

- At any point, the frequency of tremor is persistent and constant. However, it reduces during rest.
- The amplitude of tremor varies to a large extent. It is aggravated by emotional activation, extreme temperature and fatigue. Consumption of ethanol reduces the amplitude.
- Muscle cramp and reflexes are quite normal; bradykinesia or rigidity is rarely visible.

1.6 Difference between Essential Tremor and Parkinson's disease

PS and ET movement disorders are sometimes depicted as "hypokinetic" (meaning "too little movement") when a person experiences posture relaxation, or "hyperkinetic" (meaning "too meaning "too much movement") when a person experiences shaking [3].

Essential tremor and Parkinson's disease are different disorders. A number of differences exist between essential tremor (ET) and Parkinson's disease (PD), the former being at least eight times more common than PD. [4] The differences between ET and PD are given in the table as follows:

Table 1: Characteristics discussed that will help differentiate between ET and PD [4]

Parkisonian tremor	Essential tremor
The extent of amplitude is very high and the frequency range is very less.	In this, the range of amplitude frequently varies from a merely visible tremor to a high profound tremor. Also the frequency is high.
Usually perceptible at inactive state or rest.	Usually perceptible at active state..
The major symptoms are slow movements, stiffness and difficulty in walking.	Here the major symptom is tremor. Slowness, stiffness, walking and balance problems barely seen.

Here family history is a rare phenomenon (<10%).	Major cause is seen in family history (>50%).
Here both resting and postural tremor is perceptible after persistence of 5 seconds.	Here resting tremor is rarely seen. However, postural and kinetic tremor is highly perceptible.
This tremor usually starts at the age of 55.	This tremor usually starts in middle age.
The tremor onsets on a particular side of the body and advances to the other side; generally is asymmetrical.	Generally both sides of the body are initially affected. (bilateral; symmetrical).
Consumption of alcohol has no effect.	Alcohol often improves tremor.
Levodopa treatment improves this tremor.	Primidone and propranolol helps improve this tremor.
Hands are influenced more than legs, voice and head almost never affected.	Presence of tremor is preeminent in hands. Also tremor can be perceptibl in head as well as voice. Legs are barely affected.

2. Review of Literature

The research started with the study of “Handbook of Essential Tremor and Other Tremor Disorders” by Kelly E. Lyons and Rajesh Pahwa. After a deep study on the History, Pathophysiology and Tremor Analysis of Essential Tremor, the next part on focus was the invention of a technology “Liftware Spoon” that has been designed by Lift Labs, part of Lynx Design.

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2.1 History of Essential Tremor

2.1.1 Ancient history-The commendation of tremor

In Egypt, dating back to seventh century BC, hieroglyphics were used as a system for composing and recording dialect. “Trembling”, “shuddering”, or “shaking” were known to During 5000 to 3000 BC, Documentation of tremor became more exact in India. Ayurveda, being the writing arrangement during that period, it made numerous references to tremor. Tremor was denoted by the term “kampa” and irregularity due to tremor by “kampavata”. [7].

2.1.2 Early history-Distinction between rest and action tremor

Dating to 130 to 200 AD, a Turkish doctor of Pergamon, named Claudius Galen, who treated the combatants, was the first to designate tremor as an automatic movement. Later, he documented the expressions “tremor” and “palpitation” to differentiate between recognize activity tremor and rest tremor, individually [5, 8].

2.1.3 Early modern history-Identification of “Essential Tremor”

Amid the seventeenth century, there was a further refinement made between action and rest tremor. In 1680 Franciscus de la Boe, a neurologist from Holland, separated between tremor amid volitional development (motus tremulous) versus tremor very still (tremor coactus) [9]. Later, in the 1700s, Gerhard Van Swieten likewise, a Dutch doctor separated between rest tremor and intended tremor [10]. In 1817, James Parkinson, the popular English general expert, recognized vital tremor from all different tremors [11].

Additionally in the seventeenth century, it was perceived by the clinicians that some sort of tremor appeared in families. They perceived that in these families, the patients imparted a "general clinical likeness". Thus, the expression “familial tremor” was utilized to portray such cases [12].

Going to the nineteenth century, the expression "essential" was connected to numerous sickness substances of obscure reason. Such as “essential" shakings, "essential" loss of motion, and "essential" vertigo were new expressions available for use. The expression "essential tremor" was utilized to depict the genetic tremor, despite the fact that for a considerable length of time it was still all the more generally known as "familial tremor."

In 1836, a neurologist named Most depicted a few patients with a familial type of key tremor [13]. By the second a large portion of the nineteenth century, the expression "fundamental tremor" was generally utilized in neurology course books [14].

In the 1920s the clinical highlights of essential tremor was audited by a Russian neurologist, Minor. According to him, the patients with ET had higher brainpower, longer life-spans, and were more fertile. However, his statements were criticised by resulting examinations and not accepted [15]. In 1949, the most definite portrayal of the regular history and phenomenology of essential tremor were given by Critchley. He perceived that conditions known as “congenital tremor,” “infantile tremor,” “juvenile tremor,” “presenile tremor,” and “senile tremor” were all signs of key tremor, at distinctive phases of life, and were not distinct disorders [16].

2.2 Physiological Characteristics of Essential Tremor

Electromyographic (EMG) recordings are used as the current standard for recording of tremors [17–20] of the tremulous limb. Cutting edge PC innovation empowered an expansive utilization of the Fourier transform and its expansions (spectral and cross-spectral analysis) to tremor time arrangement [21, 22]. In Spectral analysis the time arrangement is transformed into the frequency area. The analysis is sensitive to rhythmic movements and thus a peak is observed at the individual frequency and is not traced and perceived by visual investigation.

Cross-spectral systems like cross-correlation or coherence can identify relationships between two simultaneously recorded tremor time arrangements [23].

2.3 Tremor Analysis

The motion of the hands are recorded accelerometrically and a defined conclusions in the depth of the tremor has been permitted by the EMG. Two types of primal mechanisms. We can take an example of limb which has ability to move to and fro motion like pendulum, furthermore it is defined as oscillatory motion. The main part is this motion is inversely proportional to weight of itself. So motion decreases with increase of weight. That means frequency decreases as the weight increases [24]. But, the muscles shows non-rhythmic isometric action which can be added to resounding motions which is the maximum portion of the tremor in physiologic point of view [25].

A peak at the tremor frequency measured by the analysis and tested through the spectral analysis accelerometrically. At this frequency, the muscle position is flat as shown in the figure 2(a). As its frequency is very low, a pure resonant phenomena can't produce pathology tremors. Low amplitude oscillation factor can produce such a rhythmic activation of motion receptor which can activate segmental or long reflex loops which can be able to enhance the oscillation. Like before the stage the spectrum cannot be remained flat but it can show a peak which is driven by the oscillation reflex loop at its tremor frequency as shown in figure 2(b).

The second mechanism occurred in CNC system (Central Nervous System) with peripheral muscles. The rhythmic activity of the muscles then leads to tremors again. Peak is shown at tremor frequency in both accelerometer spectrum as well as muscles spectrum. This oscillations are defined as central oscillation. In the accelerometer spectrum, tremor frequency will show a peak as shown in figure 2(c). These oscillations are called "central oscillations" that happens at the central frequency and are not dependent on the mechanics of limbs [26, 27]. When the limb is loaded in mechanical and physiological tremor, the tremor frequency is lowered. [20, 23, 26, 28] [Fig. 2(a) and (b)]. The central oscillatory drive increases and the mechanical-reflex component reduces and cannot be detected in the spectrum [Fig. 2(d)]. This observation has led to the hypothesis that essential tremor and the central component of physiologic tremor may share similar mechanisms which are pathologically enhanced in essential tremor [29].

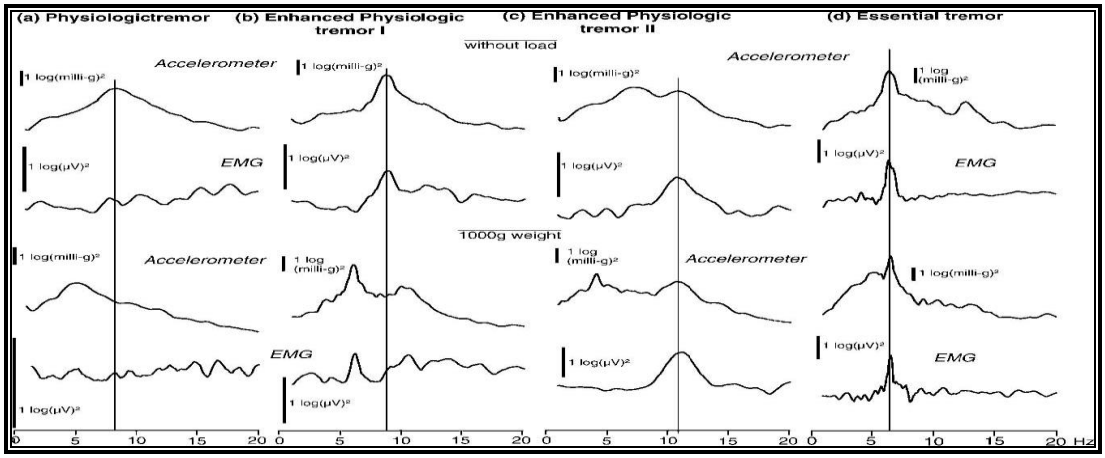


Figure2. Typical power spectra in physiological and essential tremor [5].

2.4 Nerve Responsible for Controlling Hand Muscles- Median Nerve

The median nerve is one of the main nerves originating from the brachial plexus and extends up to the fingers. It originates before the third part of the axillary artery at the lateral side [34]. The median nerve controls the forearm and hand muscles, thus allowing the wrist, thumb and fingers to bend and move. It also allows the inward rotation of the forearm palm. The median nerve convey the signals produced in the brain membrane to all parts of the fingers like index, thumb, ring and middle fingers etc/

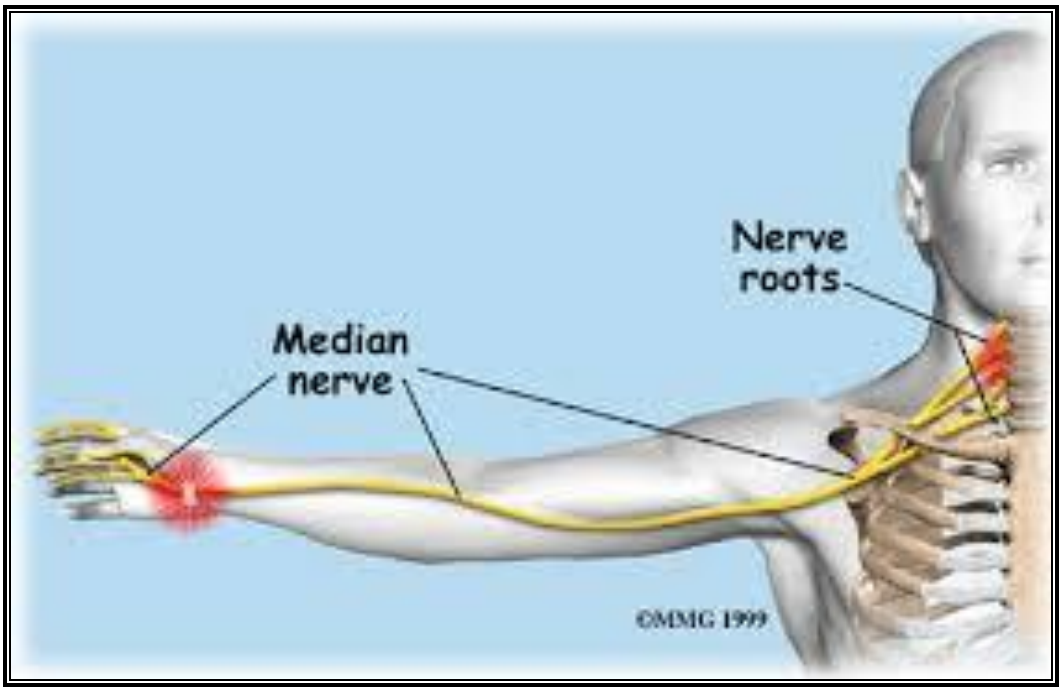


Figure3. Representation of median nerve and its origin [34]

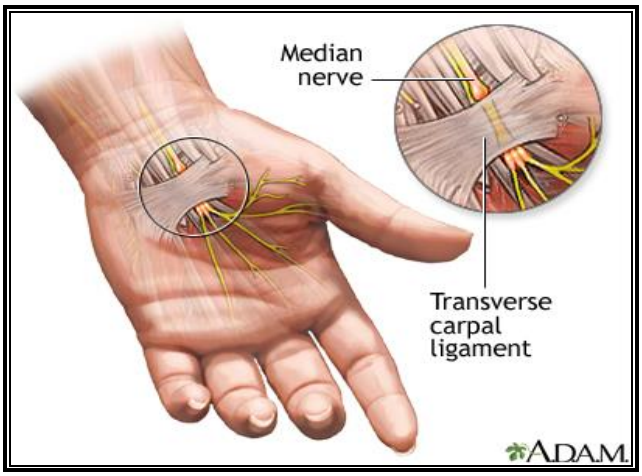


Figure4. Representation of median nerve and its branches [35]

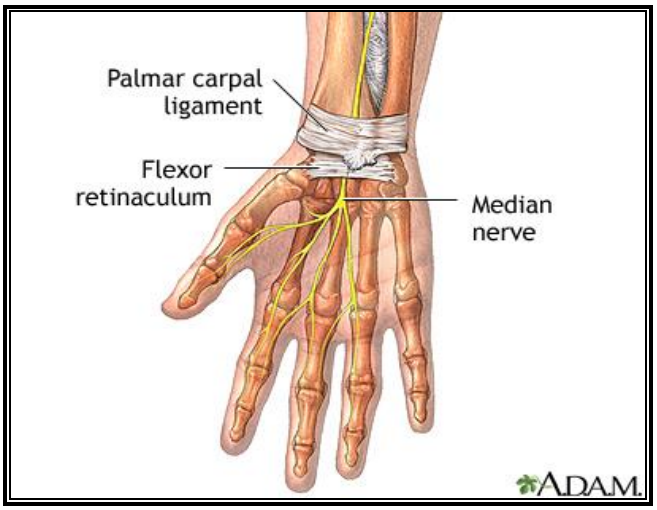


Figure5. The Median Nerve and Flexor Tendons. The median nerve and nine flexor tendons pass under the ligament bridge and through the carpal tunnel (similar to a river). They extend from the forearm up into the hand [36]

2.5 Noninvasive Hand Held Device – Liftware Spoon

The next part of the literature survey is the study of a noninvasive handheld device using Active Cancellation of Tremor (ACT) technology that could stabilize tremor-induced motion of a spoon in individuals with essential tremor (ET).

2.5.1 Liftware spoon

Liftware is a latest technology that has been created by Lift Labs, part of Lynx Design. It is designed to help older people with hand tremor eat with confidence. Liftware is a handle with stabilizing effect and contains various attachments that include a soup spoon, everyday spoon, and fork. It uses tremor stabilization technology [37] based on the research of Anupam Pathak, Ph.D., P.E.Pathak, founder and CEO of Lynx Design [39]. He explained that the idea was to use active cancellation (which is currently used in noise cancelling headphones) to stabilize larger scale motion. During his PhD at the University of Michigan, he worked on new materials that were used for active cancellation in the military. He figured out how to make the hardware for active cancellation of human tremor very small, and realized that this would be the perfect application for active cancellation technology. In his studies, Pathak noticed little technology has been developed to help people with essential tremor and Parkinson's disease. He said that people have tried

making contraptions that force a person's tremor to cease, but these looked like robotic arms that he would hate to use in public. He thought that the concept of active cancellation would be of huge help there.

Rather than forcing a hand with tremor to stop moving, which can cause pain and discomfort, Liftware responds to tremor and stabilizes what a person is trying to hold. The first product is a spoon which constantly steadies itself even while the user may be shaking. Pathak tested the technology through clinical trials involving 15 volunteer patients at the University of Michigan. A neurologist first characterized the severity of tremor for each of the participants, and had them perform basic tasks (eating, moving objects, etc.) using Liftware. The patient and neurologist were unaware whether active stabilization was turned on or off during the trial. They were able to measure with their instruments an average 75% reduction in tremor from all of the people using the device. In addition, they observed a clinical improvement in tasks involving eating and manipulating objects.

Figure6. Liftware spoon and fork attachment [39]

Funding and resources from the National Institutes of Health (NIH) facilitated early research, development, testing and plans to bring Liftware to market. In addition to Pathak's strong background in electro-mechanical engineering and materials science, the Lift Labs team includes the work of senior mechanical design engineer John Redmond,

Ph.D. and mechanical engineer Michael Allen. The potential benefits to people with ET are immediate and practical. The whole idea behind Liftware is to treat the user with dignity and respect. The liftware spoon functions like a portable eating utensil that one can use at home or take it, and it is rechargeable much like an electric toothbrush. The Lift Labs' team is also working on solutions for drinking and grooming, but will seek feedback and suggestions for products from people with ET. In the meantime, they are currently manufacturing a spoon, with a second, deeper soup spoon attachment already in the works. Pathak's vision for the use of Liftware goes beyond developing and selling a product that uses his tremor stabilization technology. Ultimately, the needs of people with tremor remain at the forefront of how the technology can be useful.

Figure7. Step procedure for using liftware [39]

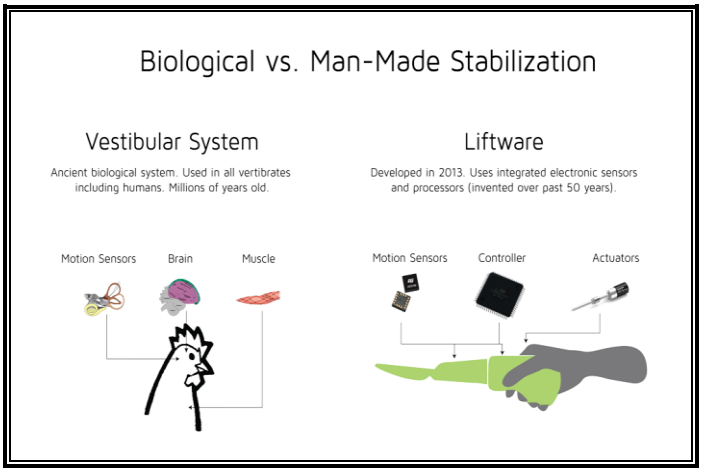


Figure8. Pictorial representation of two types of stabilization: Biological vs. Man-Made Stabilization [40]

2.5.2 Technology behind liftware spoon

The liftware spoon uses the stabilizing technology or the ACT (Active Cancellation of Tremor) Technology that is embedded in the handle. The technology consists of sensors that detect the frequency of the tremor during rest or active state and a small onboard computer that distinguishes unwanted tremor from the intended movement of the hand [41]. To stabilize the utensil, the computer directs two motors in the handle to move the utensil attachment in the opposite direction of any detected tremor. This is given as input to the microcontroller. The microcontroller by receiving the frequency and direction of the tremor, produces the output to the actuator. The actuator then nullifies the tremor by opposing the direction of tremor by moving the spoon in the opposite direction. Thus, it helps in stabilizing the tremor produced in the hands.

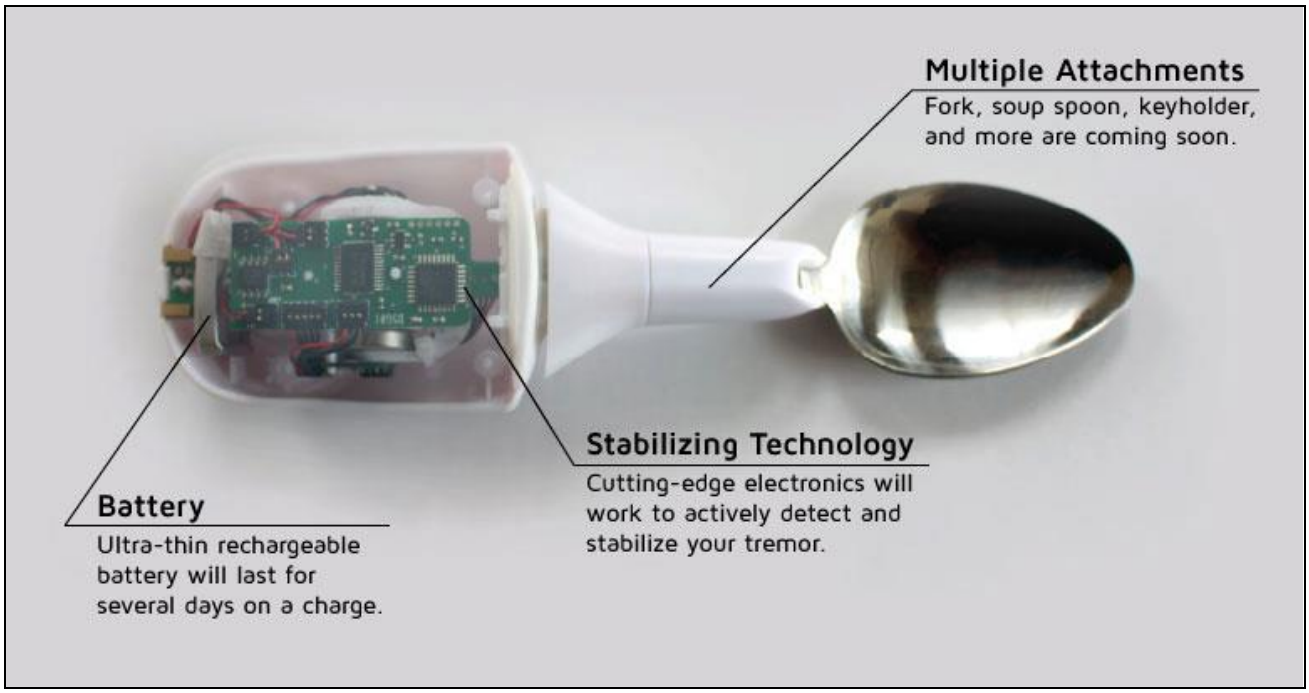


Figure9. Architechture of the liftware spoon [40]

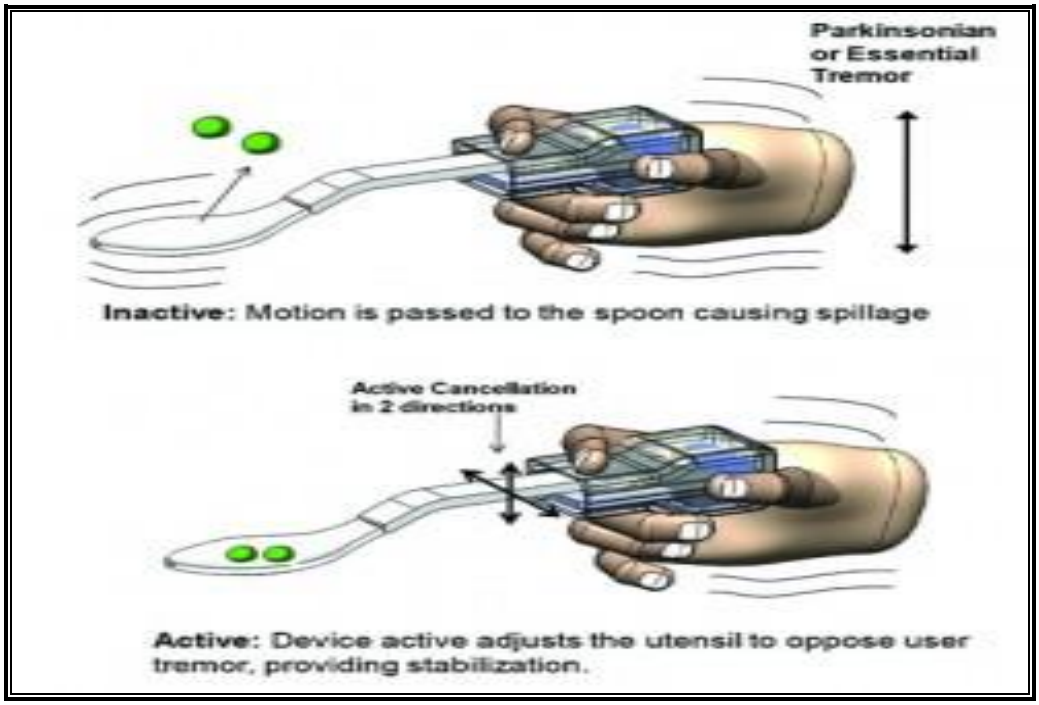


Figure10. Mechanism of the Liftware Spoon [39]

Figure11. Parts in a liftware kit [39]

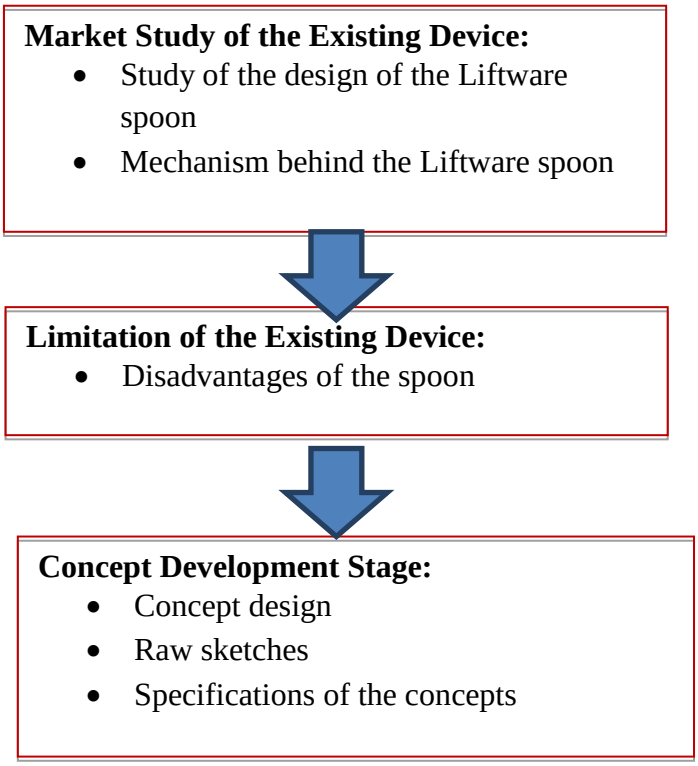
The Liftware starter kit includes the stabilizing handle and the soup spoon attachment to help people with hand tremor eat more easily. The stabilizing handle includes built-in sensors, a computer, and motors that help to sense and counteract hand tremors. The soup spoon attachment connects to the stabilizing handle to pick up food such as soups, cereals and other liquids. The soup spoon attachment holds about 1 tablespoon (15mL) of liquid. The stabilizing handle is also compatible with the fork attachment and the everyday spoon attachment. These are sold separately. We're also working on making even more attachments in future that will be compatible with the same Liftware stabilizing handle.

3. Methodology

The chapter discusses the methodology adopted to design an assistive device for older age people suffering from essential disorder which can be able to nullify the tremor produced in the hand with maximum percentage of efficiency and ergonomically designed for easy use and simultaneously help them perform their daily activities without any problems. The chapter outlines the steps followed to fulfill the objective of this project. The steps are done keeping in mind the various problems faced by the people suffering from Essential Tremor.

3.1 Flowchart for the methodology

The methodology of the research starts with the market study of the existing device i.e. the Liftware spoon and the mechanism behind its working. The second step is the limitations of the spoon when used by the people with ET. The third step is the concept development stage in which concepts are designed keeping in mind the limitations of the existing device. The fourth step deals with the survey of the prerequisites for the concepts. This includes the survey of the average frequency in hands of older people suffering with ET as well as the average size of the wrist of old people. This would help in giving the concepts a detail design. Fifth step includes selection of the final concept from the given concepts by analysing the various pros and cons of the designs. The sixth step deals with deciding the technology and mechanism behind the final concept. The seventh step is the modelling stage. In this step, the final model is designed in Solid Works software and the simulation is also done. The eight step begins with the material selection and the detail design of the final concept which includes the geometry and size of the product. Next step is the technical specifications of the final concept. This includes the technical specifications of each part used in the device, their geometry and other specifications. The final step is the prototyping stage. In this step the final model is prototyped using the 3D Printer of the Industrial Design Dept., NIT Rourkela. After prototyping is completed, the testing of the device is done. The flowchart for the methodology steps are given as follows:-



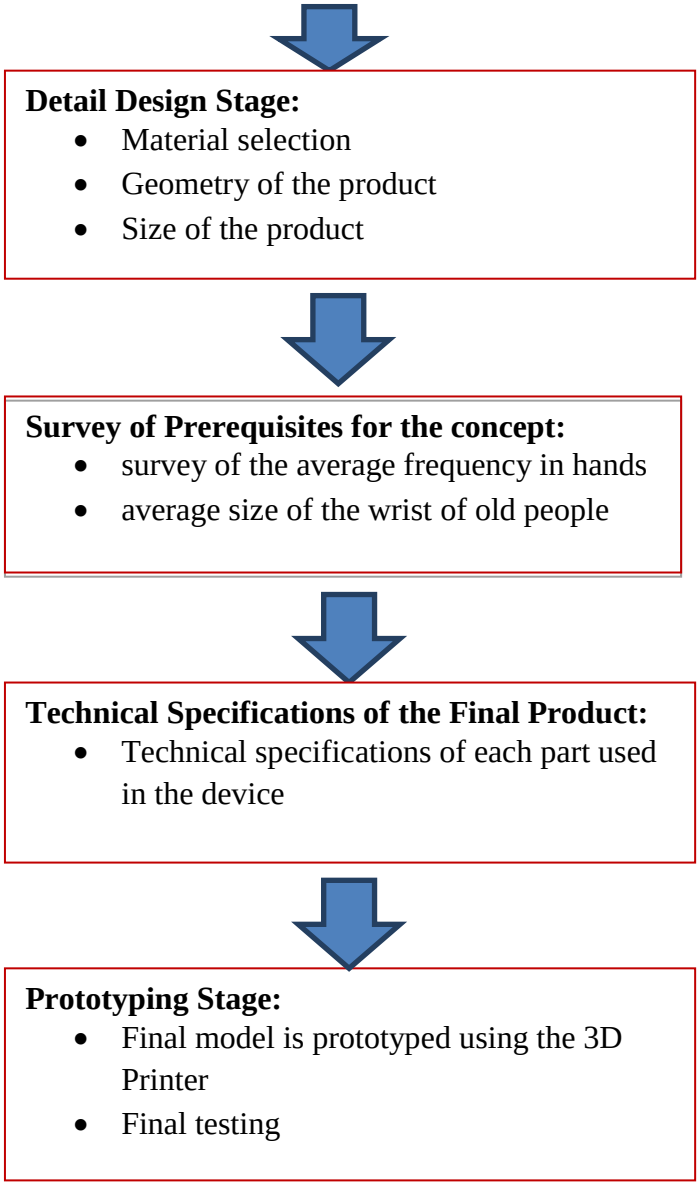


Figure12. Flow chart for the methodology followed.

The various steps that are followed in the research project are explained in detail as follows:

3.2 Market Study of the Existing Device:

Liftware spoon is an assistive device for people suffering from ET. It consists of a spoon that shakes to counterbalance hand tremor in which the tremor is produced due to essential tremor. It is designed to help older people with hand tremor eat with confidence. Liftware is a handle with stabilizing effect and contains various attachments that include a soup spoon, everyday spoon, and fork. It uses tremor stabilization technology. Rather than forcing a hand with tremor to stop moving, which can cause pain and discomfort, Liftware responds to tremor and stabilizes what a person is trying to hold.

Figure13. Liftware spoon [40]

Technology used:

- Switchless spoon starts automatically when it is lifted from the table, thechunky handles vibrates a little on the user's hand.
- There is a little motion sensor right near the spoon. If someone had tremor, it is going to move opposite to what the shaking is doing. So if someone moves to the left, it physically moves the spoon to the right.

3.3 Limitations of the Liftware spoon

Liftware spoon is a well-designed assistive device for old people suffering from ET.
However, its use in practical life is limited. Because the spoon can be utilized only while eating. Old people suffering from ET also experience difficulty while writing and holding something. The liftware spoon doesn't address these problems.

3.4 Concept Development Stage

After going through the literature review and the problem statement, the objective of this work is to design a device for people suffering from ET. This device would help to nullify the tremor produced not only during eating, but also during writing or holding something. The main objective of the project is focusing on the design of an intelligent device that can recognize the tremor automatically by differentiating the frequency at normal stage and at the shaking stage in order to accomplish the neutralizing effect in the shortest possible time.

The only limitation of the Liftware spoon is that it has its limited use, i.e. during eating only. So the first thing on focus is the structure of the device which can be used by the old people for doing the daily activities like eating, writing or holding something. So it is decided to design a wrist band type device which the old people can tie over their wrists while doing their daily activities. The band with all the technology embedded in it is ergonomically designed to suit the people so that they won't feel uncomfortable while using it.

3.4.1 Concept 1

Keeping all the data in the mind, the first concept regarding the architecture of the device is that the device has taken the shape of a wrist watch, as result it can be very much convenient way to use with maximum efficiency. The different part of the product has been shown in the below figure.

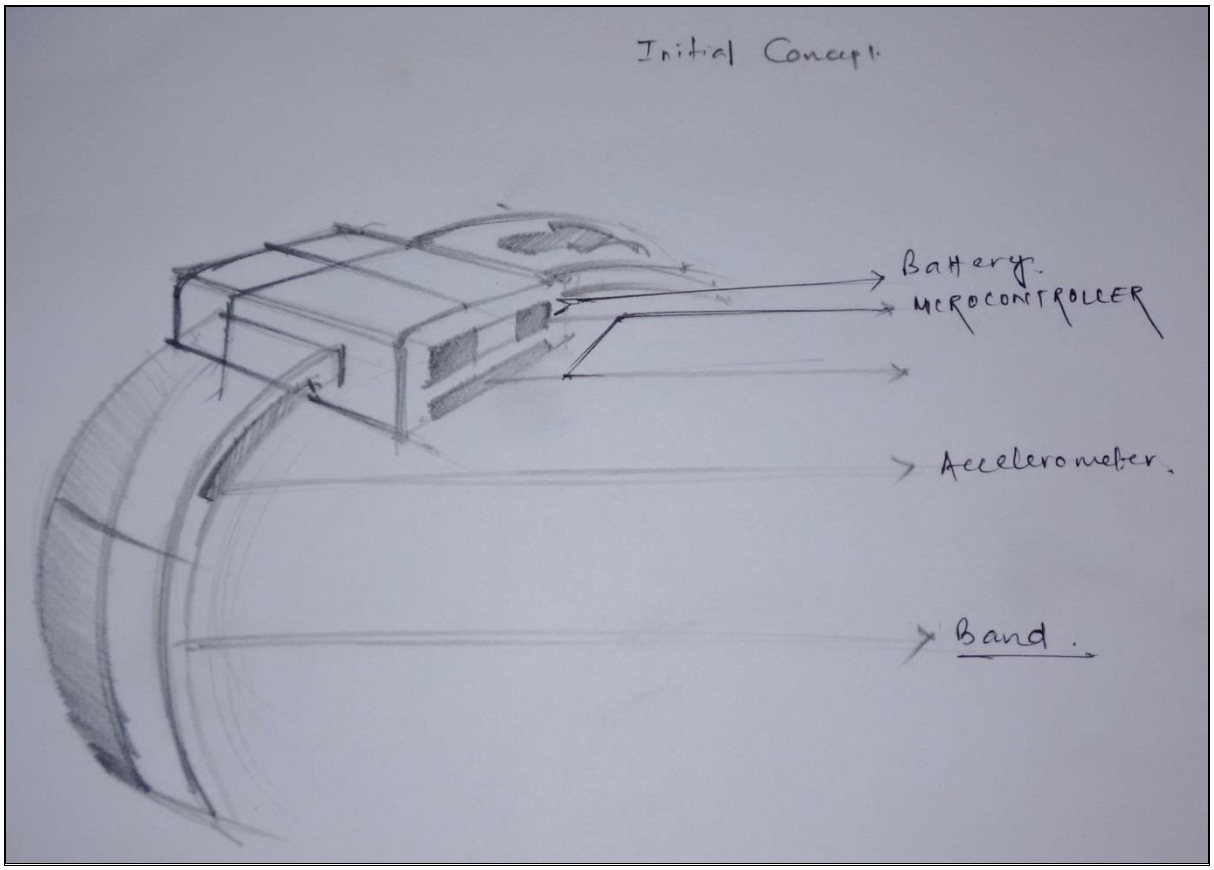


Figure14. Sketch of concept 1

As shown in the figure the accelerometer senses the position of the hand by getting pulse from the median nerve. Then the accelerometer measures the position with respect to gravitational force parameter. Then it will give input to the nano-microcontroller which is positioned under the rechargeable battery. The instant the microcontroller gets the input it will give an output signal to the actuators present in the band casing. The actuator works opposite towards the position of the hand which is programmed with respect to accelerometer results.

The modelling of the above concept is done using the Solid Works software. The simulation is also done in the Solid Works work bench.

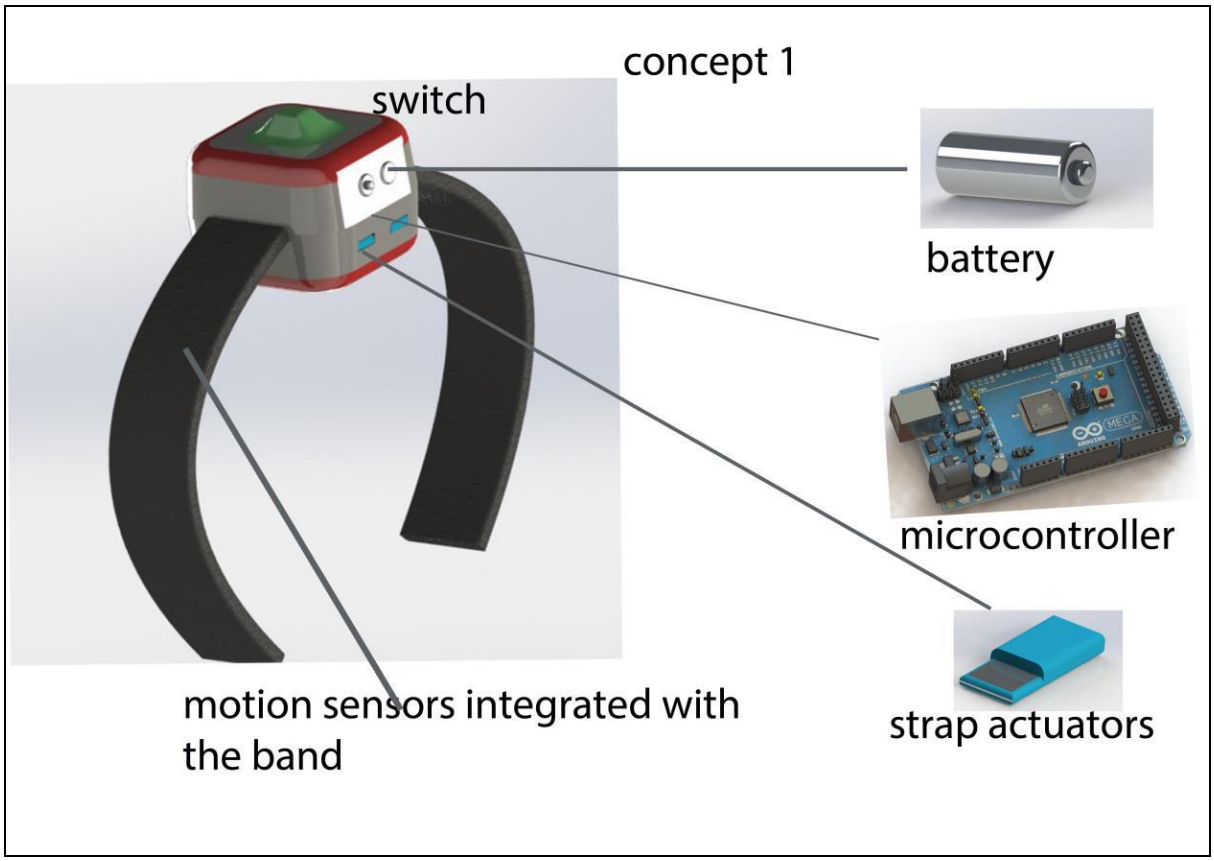


Figure15. Concept 1 CAD Model

3.4.2 Disadvantages of concept 1

According to this design, the actuators are not properly working because the actuator itself can't provide sufficient vibrational force to nullify the vibration produced due to the neurological disorder. As the actuator positioning is under the microcontroller, so the vibrations produced due to the actuators hampers the connection of microcontroller's wirings and reduces the safety factor between the power source and the microcontroller.

Additionally in this concept, the frequency of the vibration of the hands of the person suffering from ET is not taken into account. So before going to the next concept in this paper we have presented the survey taken from the journal of "Neurology, Neurosurgery and Psychiatry" [42]

3.5 Survey of Prerequisite

15 patients with ET were included in the study. 60% of the patients had a family history of tremor. Clinical testing consisted of a neurological examination and a classification and grading of tremor of the hands and arms. [42]

The grading included a clinical rating of the amplitude of the tremor. Tremor under resting conditions was accepted, when it occurred while sitting in a comfortable chair with relaxed arms. Tremor under postural conditions was accepted if it occurred with outstretched arms. Action tremor which occurred when performing alternating flexion/extension movements of the hand. Furthermore the behaviour of the tremor was rated when the mode of innervation changed from rest to postural conditions or from posture to goal-directed movements. In all the patients the frequency of the tremor at the wrist joint was measured with an accelerometer. [42]

Table 2: Criteria for grading of tremor in hands and arms under defined conditions [42]

Tremor under resting conditions (tested sitting in a relaxed position with supported arms) 0: no tremor 1: intermittent tremor, small amplitude, which can be activated by mental load 2: constant tremor with variable amplitude below 10cm 3: constant tremor with amplitudes over 10 cm and which may not be suppressed voluntarily
(tested by holding a water filled glass with outstretched arms) 0: no tremor 1: tremor of low amplitude without spilling water 2:moderate tremor with Tremor under postural conditions intermittent spilling of water 3: tremor of large amplitude and severe spilling of water
Tremor under action conditions A(slow alternating flexion/extension movements of hands and arms) 0: no tremor 1: slight tremor amplitudes

2: moderate tremor amplitudes 3: large tremor amplitudes B(goal-directed movements: finger-finger-finger-nose-Test) 0: no tremor 1: slight tremor amplitudes 2: moderate tremor amplitudes 3: large tremor amplitudes
Transition among different conditions Rest to posture 0: suppression of tremor 1: unchanged tremor 2:enhanced tremor Posture to goal-directed movements 0: suppression of tremor 1: unchanged tremor 2:enhanced tremor

Table 3: Clinical data of 15 ET patients surveyed [42]

Sl.no.	Age (years)	Sex	Hereditary	Duration(yr)	Transition R to P	Transition P to B	Frequency (Hz)
1	60	F	+	9	Ø	0	7.0
2	61	M	+	5	Ø	0	7.0
3	63	F	+	4	Ø	1	8.0
4	62	F	Ø	5	Ø	0	7.5
5	62	F	+	6	Ø	1	7.0
6	60	F	Ø	7	Ø	0	6.0
7	65	M	+	9	Ø	0	6.3
8	74	M	Ø	9	2	2	6.8
9	75	M	+	11	Ø	1	7.1
10	77	F	+	12	2	1	7.3

11	74	M	Ø	6	2	1	7.5
12	76	F	Ø	7	2	1	7.0
13	76	F	+	6	2	1	7.0
14	73	M	+	7	Ø	2	7.5
15	80	F	+	15	2	2	7.5

Ø-not applicable

+-applicable

The average frequency is found to be 7.0 Hz. Taking this average frequency in this project, the next concept has been designed.

3.5.1 Concept 2

Keeping in mind the disadvantages of the previous concept, it has been decided to go for the next concept. In the next concept it is decided to multiply the force or vibrations generated by the actuators by giving some torque incorporating catalyst and also giving importance to the safety factor of the device by positioning the components safely with proper insulation and cushions in the band.

The raw sketch of the modified concept is as follows:

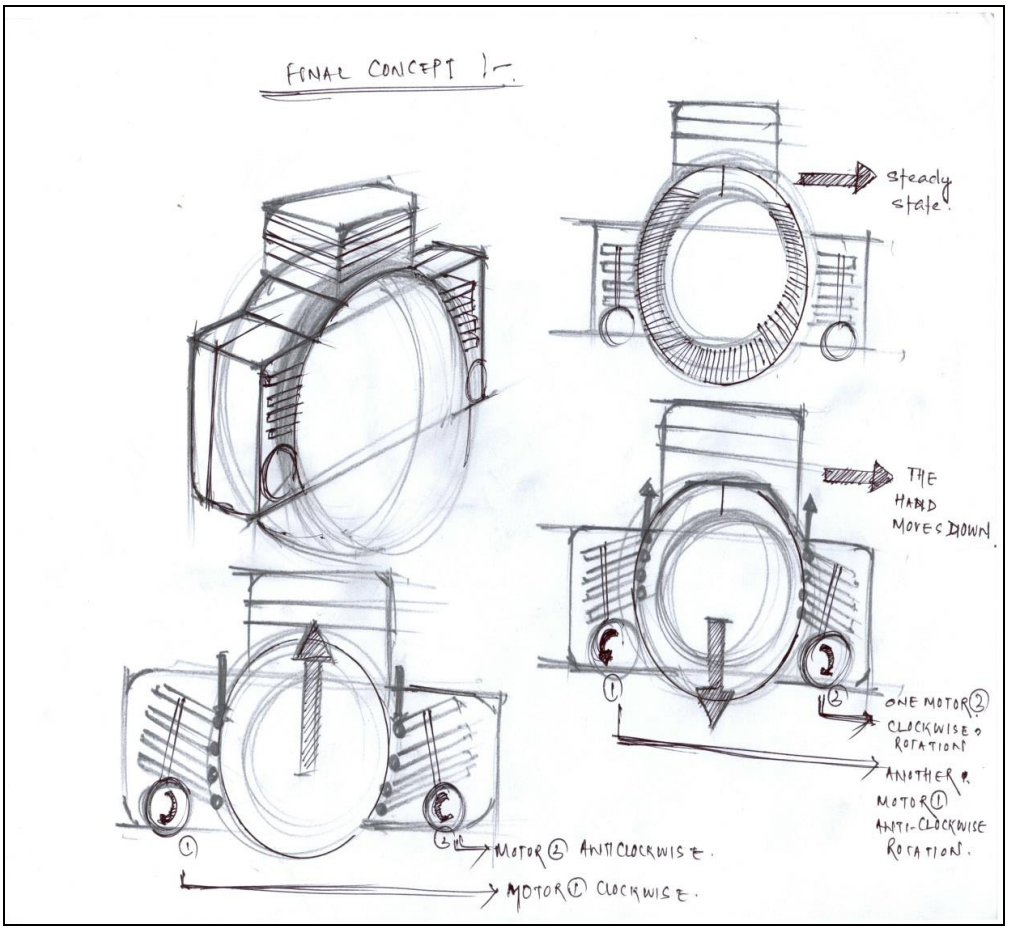


Figure16. Sketch of concept 2

The mechanism displayed in the above figure represents that the actuators are integrated with some fins which act like torque giving catalyst helps to give sufficient torque to produce maximum vibrational force which can nullify the vibrational force produced in the hands of people suffering from ET. The detailed mechanism is divided into 2 categories such as:

- When the hand is moving upwards
- When the hand is moving downwards

Case 1: When the hand is moving upwards:

In this case, when the hand is moving upward, the accelerometer senses the position of the hand using its gravitational force parameter by giving the results in X-Y-Z coordinates. According to the coordinate results, the movement of the hand can be identified. At that

instant, input signal goes to the microcontroller for activating the actuators. Again the two actuators are programmed to act in opposite directions.

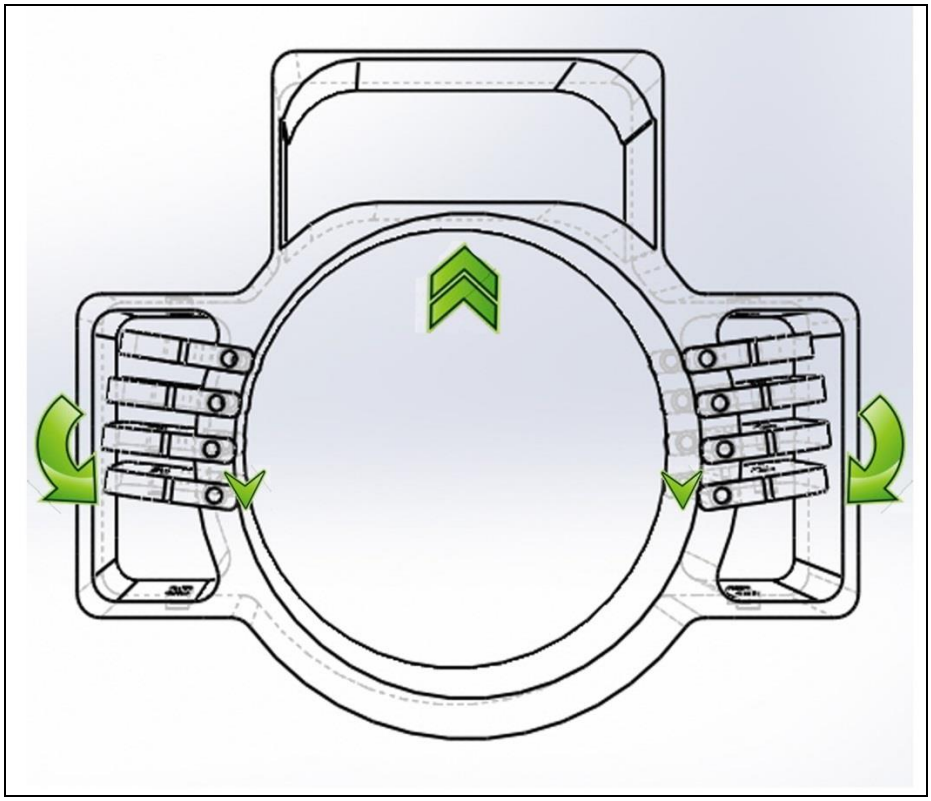


Figure17. When the hand is moving upwards

As shown in the figure 3.6 the actuators are integrated with fins with a small belt which are actuated or vibrated due to the action of actuators. After getting an output signal from the microcontroller, motor 1 is actuated in an anti-clockwise direction. As a result, tension is produced in the belt which pulls the fins in downward direction which results in an upward force at the point where the revolute joint is present between the fins and the band. Again at the same time the motor 2 is actuated in a clock-wise direction, and giving the same action as explained for motor 1.

Case 2: When the hand is moving downwards:

In this case, when the hand is moving downward, the accelerometer senses the position of the hand using its gravitational force parameter by giving the results in X-Y-Z coordinates. According to the coordinate results, the movement of the hand can be identified. At that instant, input signal goes to the microcontroller for activating the actuators. Again the two actuators are programmed to act in opposite directions.

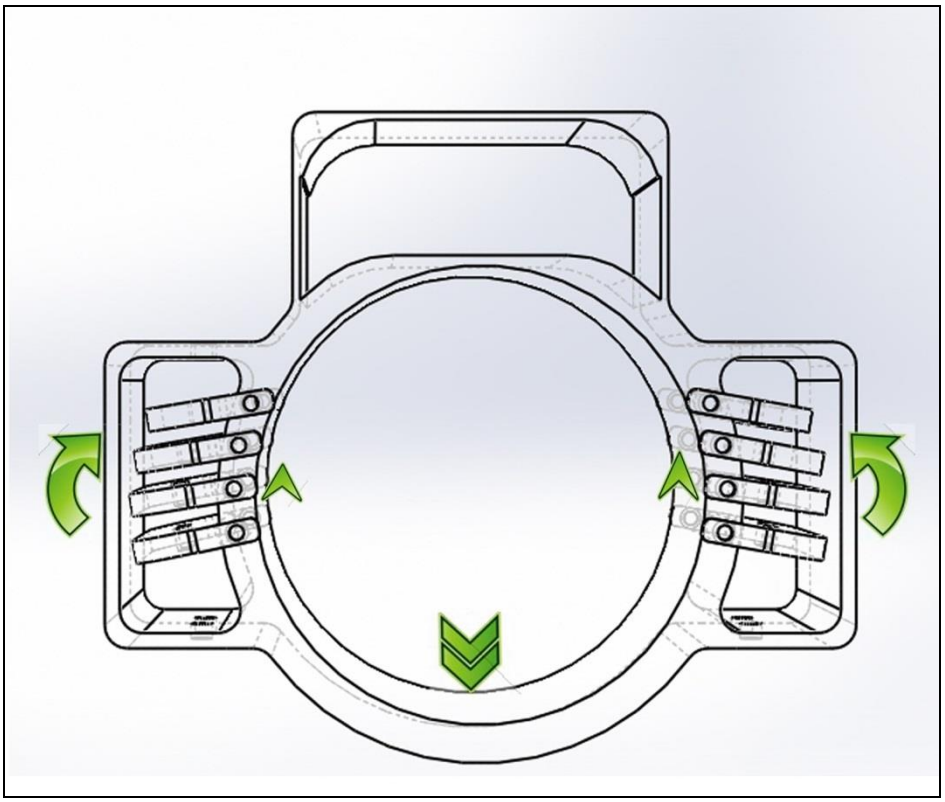


Figure18. When the hand is moving downwards

As shown in the figure 3.7 the actuators are integrated with fins with a small belt which are actuated or vibrated due to the action of actuators. After getting an output signal from the microcontroller, motor 1 is actuated in a clockwise direction. As a result, tension is produced in the belt which pulls the fins in upward direction which results in an downward force at the point where the revolute joint is present between the fins and the band. Again at the same time the motor 2 is actuated in an anti-clockwise direction, and giving the same action as explained for motor 1.

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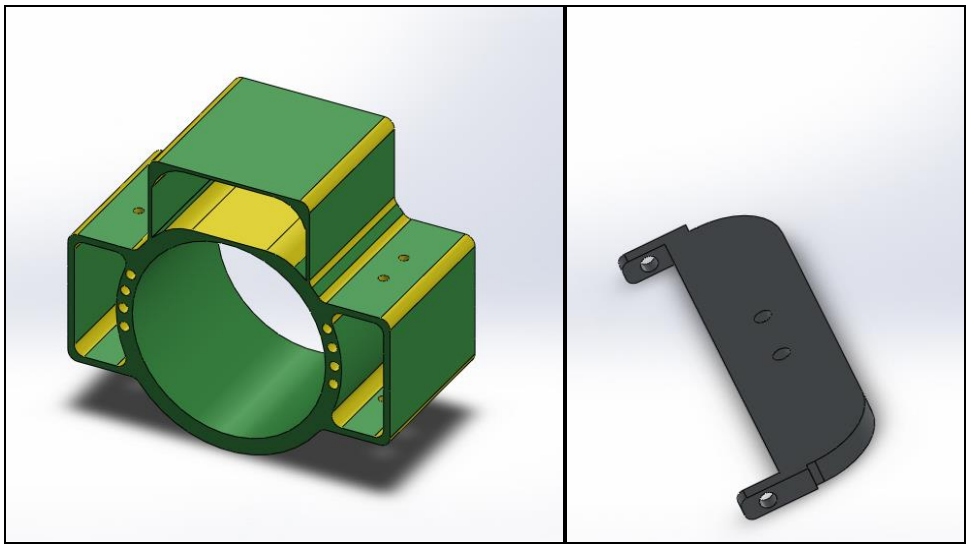
4. Results and Discussions

The chapter deals with the results obtained from the study conducted. A design framework is proposed here which gives the final concept. The final model is completed in Solid Works software keeping in mind all the dimensions of the parts of the model. The final model is an intelligent device that can recognize the tremor automatically by differentiating the frequency at normal stage and at the shaking stage in order to accomplish the neutralizing effect in the shortest possible time. After recognizing the frequency, the additional fins help in giving a torque to the direction opposite to the direction of the hand tremor.

4.1 Design Framework

In the final concept as it has been discussed earlier, the force or vibrations generated by the actuators is multiplies by giving some torque incorporating catalyst and also giving importance to the safety factor of the device by positioning the components safely with proper insulation and cushions in the band.

CAD model of the final concept in detail using Solid Works:



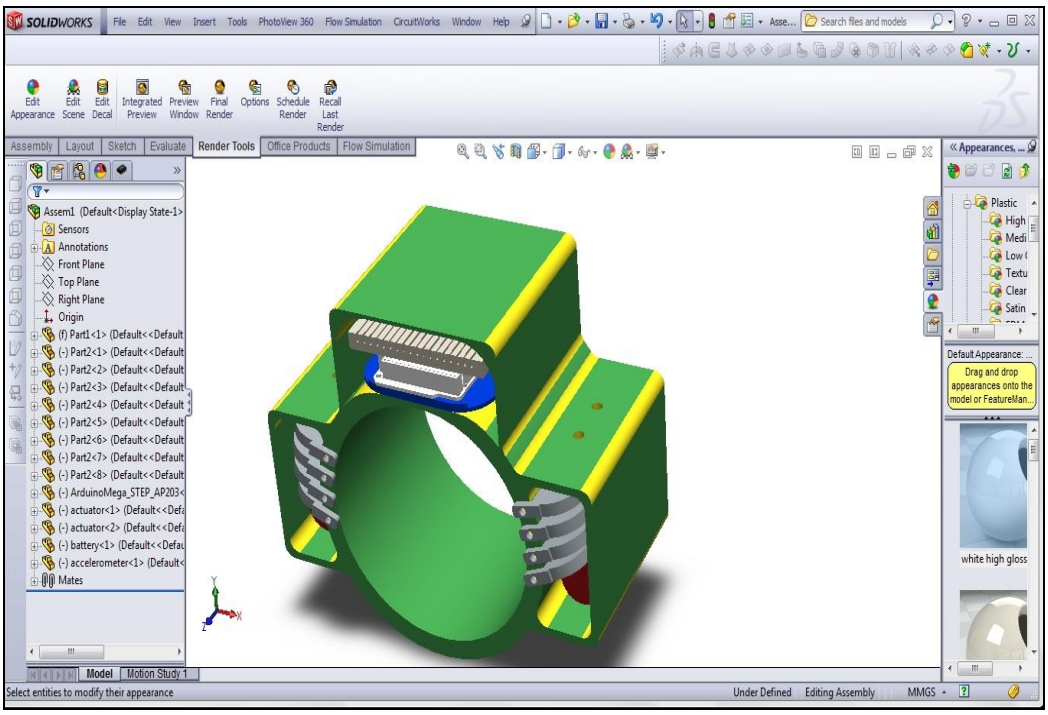


Figure19. CAD model of concept 2

4.2 Selection of the Final Concept

Considering the disadvantages of concept1 and following advantages of concept2, it has been concluded that the concept2 is able to give efficient result on the basis of the requirement according to the survey. The incorporation of additional features like the fins which act like torque giving catalyst helps to give sufficient torque to produce maximum vibrational force which can nullify the vibrational force produced in the hands of people suffering from ET. Thus the concept2 is selected over concept1 and next the detail design of the concept2 is discussed in the next section.

4.3 Detail Design Stage

The detail design stage includes the geometry and drafting of the product. It also includes the selection of the material for the device.

4.3.1 Geometry and drafting of the product

In this section the detail dimension of the final product has been given as well as the rendered view of the product is given below:

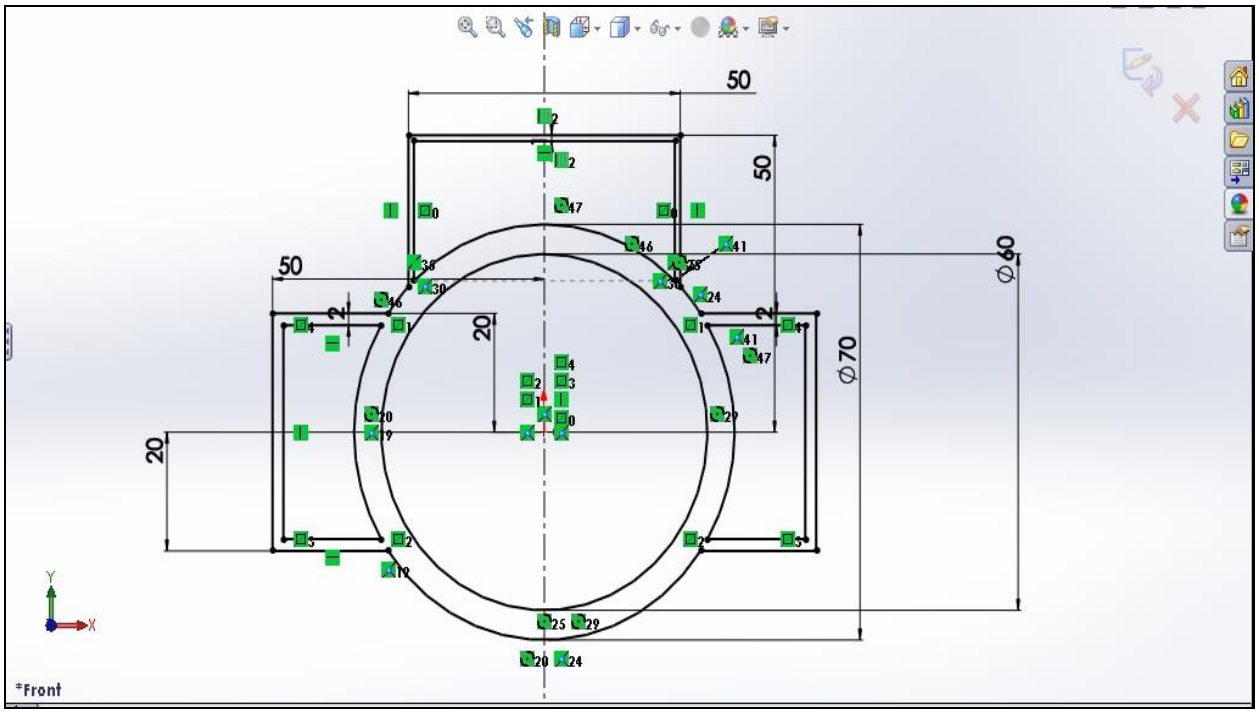


Figure20. Drafting view of the frame with its dimensions

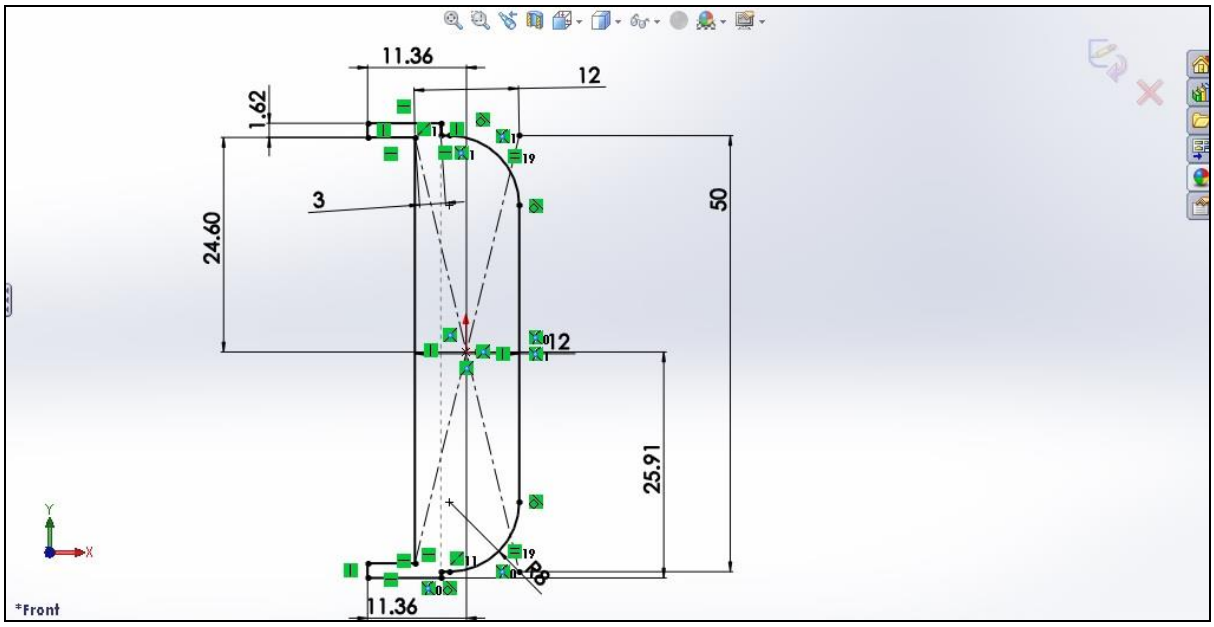


Figure21. Drafting view of the fin with its dimensions

4.3.2 Rendered view of the product

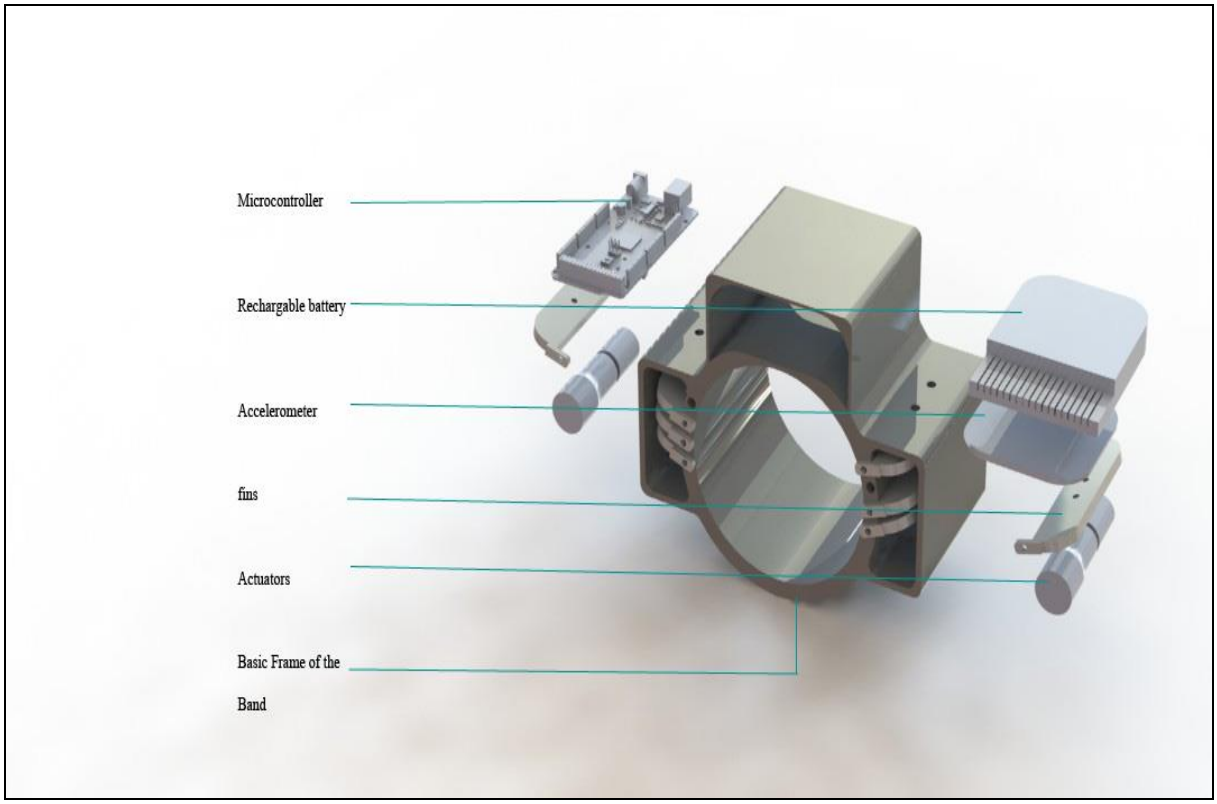


Figure22. Detailed disassembled view of the final product

Here the model is disassembled to show the various parts of the model like microcontroller, rechargeable battery, accelerometer, fins, actuators, basic frame of the band.

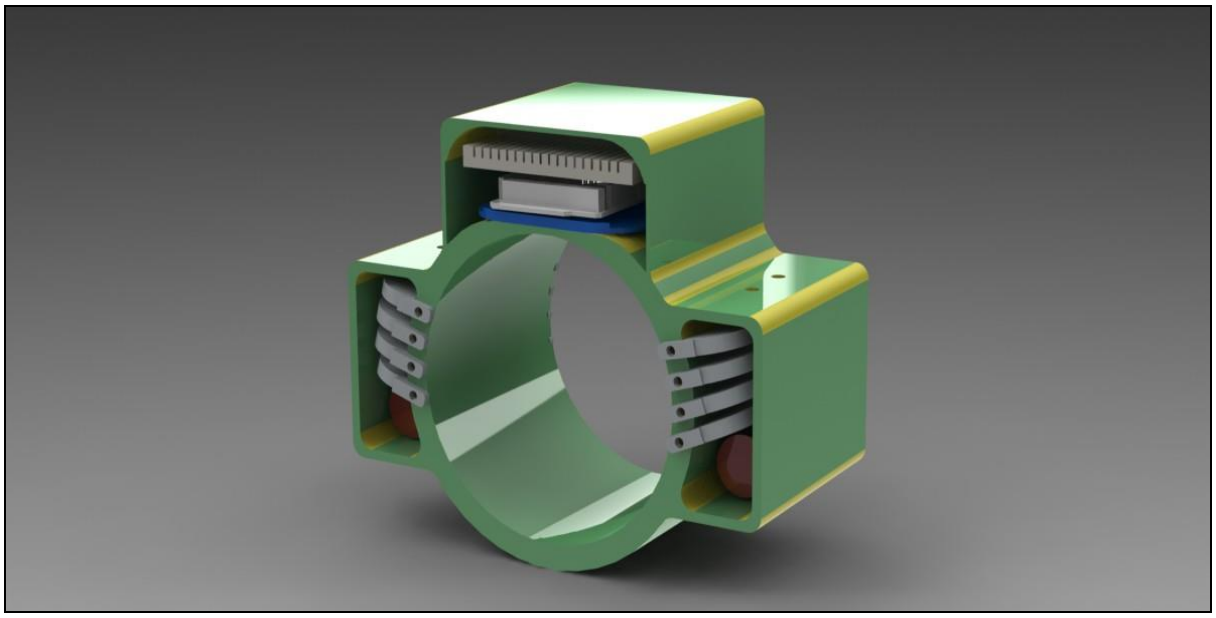


Figure23. Rendered view of the final assembled product

4.3.3 Material selection

Before going to consider the material for the final product, we have considered the basic comfort and ergonomic details of elderly people. According to these factors we have designed the device with proper cushion in the basic frame which is made up of leather because leather is very flexible and usable for various sizes of the wrists.

Next for the fins it has been decided that the material is composite reinforced plastic as it can give the required amount of torque that is needed.

4.4 Technical Specifications of the Final Product

Table 4: Overall dimension of the product

Dimensions	
Specifications	Measurement
Overall length	50mm
Overall width	100mm

Overall height	80mm
Weight	110grams
Volume	106341.72 cube mms
Surface area	80282.88 square mm

Table 5: Specification of the parts of the device

Component specification	
Actuator	Crazyflie 2.0 Nano Quadcopter Coreless Motor 7*16mm
Microcontroller	F04878-C Nano V3.0 ATMEGA328P
Accelerometer	2-axis accelerometer

Software used	Solid Works and Arduino

4.5 Prototype of the basic frame

Figure24. Prototype of the basic frame

The prototype of the frame was designed using the 3D Color Printer in the Industrial Design Department of NIT Rourkela.

4.6 Scope of the Work

In this work the CAD model of the final design has been presented. The simulation of the model has been done. It has justified the working of the model in the virtual environment. The basic frame of the design is completed and further more electronics work and the practical testing is to be done.

5. Conclusion

Essential tremor (ET) is one of the most common neurological disorder and has influenced individuals from the earliest starting point of cutting edge human presence. Essential tremor is characterized by uncontrollable shaking or tremors in different areas of the body like hands, arms etc. It often affects activities of daily living, including writing and eating. The persistence of ET increases with advancing age and is usually characterized by presence of postural and kinetic tremor. The tremors worsen when the hands are being used (kinetic tremor) and reduce significantly when the hands are resting. Also the condition worsens when people affected with ET, hold their body is certain postures (posturaltremor).Generally speaking, essential tremor gradually gets worse over time and with advancing age. The cause is unknown and there is no cure, although drugs and surgery may help. Older people are more susceptible. This paper describes research on the development of sensor based assistive device for neutralizing tremor in hands of old people. The main objective of the project is focusing on the design of an intelligent device that can recognize the tremor automatically by differentiating the frequency at normal stage and at the shaking stage in order to accomplish the neutralizing effect in the shortest possible time. Ideas to develop the device in small scale is to investigate the average frequency of shaking of hands during relaxed posture, postural conditions, action conditions, transition positions etc. and to achieve the require time to deliver the task. Experiment show that the system is robustness and well positioned with different frequencies to achieve the targeted task of nullifying the tremor produced in the hands with maximum percentage of efficiency and ergonomically designed for efficient use.

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